Lab-Built Wheat Gene May Raise Dough Quality

BRIAN PRECHTEL (K8240-15)

Geneticist Kent McCue examines the growth of wheat plants that have received a gene for modifying starch production.

Wheat plants of the future might provide grain for designer flours that yield delicious, wholesome new breads, pastas, and other appetizing foods. And giving some of wheat's flour genes to other kinds of grains—barley, oats, corn, rye, or rice, for instance—could lead the way to innovative, versatile flours from these wheat relatives, as well.

These futuristic flours are the target of genetic engineering experiments conducted by Agricultural Research Service scientists at the Western Regional Research Center in Albany, California. They are investigating proteins unique to wheat flour, called high-molecular-weight glutenins. These glutenins are critical to making strong dough. For dough, strength is an asset because it leads to high-quality yeast-raised breads.

Strong dough, explains geneticist Olin D. Anderson, is able to trap tiny bubbles of carbon dioxide gas formed naturally by yeast during mixing and rising. Bubbles enable dough to rise, helping form high, light, loaves. Dough strength and the ability to contain gas bubbles is known as viscoelasticity.

Wheat with a large amount of certain high-molecular-weight glutenins yields flour that produces stronger dough, larger bread loaf sizes, and light, finer-textured breads. Recently, Anderson and geneticist Ann E. Blechl became the first to use genetic engineering to boost the amount of high-molecular-weight glutenins in wheat kernels and the flour ground from those kernels. They did this by using a gene gun to move copies of a lab-built gene into wheat cells.

The gene gun fired gold particles coated with genes that cue wheat plants to manufacture more glutenins. So far, greenhouse plants with high levels of high-molecular-weight glutenins retained the trait through successive generations.

The researchers now want to fine-tune this strategy for more precise control over wheat flour's glutenin levels. With colleagues from Australia's Commonwealth Science and Industrial Research Organization in Sydney, they are testing flours made from kernels harvested from these experimental plants.

No one knows exactly how high-molecular glutenins work—only that they're vital for strong doughs and great breads. To reveal more about the inner workings of these proteins, Anderson is building and testing

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At the ARS Western Regional Research Center in Albany, California, geneticist Olin Anderson uses a sample-handling robot to search more efficiently for new wheat genes. It can prepare DNA, identify specific genes, and perform other functions—often faster and more accurately then a human.

modified versions of other genes that control production of glutenins.

Some of these re-tooled genes are longer versions of the naturally occurring ones. Their central sections have more repeats of a portion of genetic material thought to be key to viscoelasticity. Anderson's tests showed that increasing the copies of those portions of the genes increases dough-mixing time. That's a boon to bakers, because increased dough-mixing time is a key indicator of dough strength.

Scientists have anticipated that using genetic engineering to change a wheat-flour protein could change the character of the resulting dough. The Albany team was the first to succeed in doing that—using biotechnology.

Wheat glutenin genes inserted into other grains may lead to unique, healthful products impossible to make today. Moving one or two of wheat's high-molecular-weight glutenin genes into barley, for example, might open the door to popular new products from barley flour.

Currently, American-grown barley is used mainly for malting and animal feed. Barley flour lacks the high-molecular-weight glutenins that wheat flour boasts. Although barley has flour proteins somewhat similar to those in wheat, barley flour does not make a similar viscoelastic dough.

Now, senior lab technician Jeanie Lin, who is with the Albany team, has succeeded in moving wheat glutenin genes into barley plants. And, says Lin, some of those plants produced kernels with good levels of wheat glutenin inside.

In another venture, Minnesota scientists using wheat glutenin genes furnished by the Albany researchers have produced oat plants with the borrowed wheat genes inside. David A. Somers led that work at the University of Minnesota. He used a technique that he, Kimberly A. Torbert, and geneticist Howard W. Rines of the ARS Plant Science Research Unit in St. Paul, Minnesota, developed for genetically engineering oats.

Like the barley foray, oat experiments may lead to development of tasty new foods that rely on new oat flours. Today's oats are grown mostly for animal feed or processed into breakfast cereals and other foods for people.

The glutenin experiments with wheat target the protein-rich portion of wheat flour. But flour's other main component—starch—might also be re-worked through genetic engineering into a more marketable product.

Wheat starch is composed of molecules known as amylose and amylopectin. Wheat flour low in amylose, for example, is desirable for noodlemaking because it improves noodle texture. Reduced-amylose flours may also improve dough for frozen foods like pizza crusts or ready-to-bake breads by helping maintain flavor.

Scientists suspect that boosting the amount of amylopectin in starch may concurrently reduce the amount of amylose, resulting in a value-added, low-amylose flour.

Geneticist Kent F. McCue, working with Anderson, isolated two genes that direct wheat to make amylopectin-producing enzymes known as starch-branching enzyme I and starch-branching enzyme II. McCue and Anderson used starch genes from corn to isolate the two in wheat. With the wheat genes now in hand, genetic engineers might soon be able to increase the ratio of amylopectin to amylose.

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Modifying wheat starch could also make it more suitable for any of hundreds of industrial uses ranging from pastes to papers to textiles. —By **Marcia Wood,** ARS.

For more information on U.S. Patent No. 5,650,558, "Glutenin Genes and Their Uses," *Patent Application No. 08/785,716,* "Altering Dough Viscoelasticity With Modified Glutenins," *or Patent Application No. 60/059,257,* "Modification of Starch Branching Patterns and Chain Length Distribution Via Transformation with Starch Branching Enzymes," *contact Olin D. Anderson, USDA-ARS Crop Improvement and Utilization Research Unit, Western Regional Research Center, 800 Buchanan St., Albany, CA 94710; phone (510) 559-5773, fax (510) 559-5777, e-mail oandersn@pw.usda.gov.* ◆